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BOVINE AND PORCINE SOMATOTROPIN

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Introduction

Among the more recent biological tools being proposed and studied for dairy and swine management programs is somatotropin (growth hormone or GH). Advocates claim that somatotropin improves efficiency and thus decreases the cost of production in dairy cows and growing swine.^{1,2} With Food and Drug Administration (F&DA) approval of bovine somatotropin (BST) expected within the year in the United States and approval of porcine somatotropin (PST) being sought, food animal veterinarians need to be knowledgeable of somatotropin and must be prepared to advise clients on the use of the product as a management tool.^{2,3}

History

Somatotropin has received much recent attention but information about it goes back many years. Injection of crude pituitary extract was shown to stimulate milk production of cows in 1937.⁴ Bovine pituitary extracts were injected into cows in England to stimulate milk production during World War II. Those early systems were impractical, however as preparation of a single dose required 25-100 pituitary glands.¹ In 1972 researchers injected highly purified PST into pigs and found it stimulated growth and produced carcasses with more protein and less fat. In 1973 injection of purified BST was found to increase milk production in cows.⁴ More recently, the development of

recombinant deoxyribonucleic acid (DNA) technology has provided a mechanism for large scale production of GH. The gene for GH protein was inserted into a laboratory strain of *Escherichia coli* which can be grown on large scale and from which GH is purified and concentrated for use.¹ In 1980, daily injections of recombinant methionyl GH (met-BST) increased milk production in cows.⁵

Growth hormone secretion

Somatotropin is a small, single chain polypeptide secreted by the pars distalis of the adenohypophysis. Its structure varies between species. Its release is stimulated by growth hormone releasing factor (GHRF or GNRH) produced in the hypothalamus. Somatostatin, another hormone produced by the hypothalamus acts directly on the adenohypophysis of the pituitary gland to inhibit GH release.⁶ Use of GHRF to enhance endogenous GH secretion has thus far been less effective than exogenous GH in stimulating growth and lactation.⁷

A wide variety of factors influence GH secretion. Variables include nutritional status, species and individual differences, sex differences and emotional status. Experimental design and comparison of data with previous studies are thus very difficult.

Plasma GH concentrations are higher in underfed compared with adequately fed cows, pigs and sheep. The increased GH release may mobilize energy from adipose tissue to satisfy metabolic needs. Implanting estrogenic anabolic compounds in steers increases the secretion of GH. The primary metabolic controller of GH release in ruminants appears to be plasma concentration of free fatty acids (FFA). As plasma FFA decreases, the plasma GH increases.⁵

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Growth hormone physiology

GH is species specific but has many similar physiological effects across species. GH promotes skeletal growth, protein synthesis, hepatic glycconeolysis and lipolysis within adipose tissue.⁶ Skeletal growth is promoted by increasing cell replication and the formation of collagen.^{5,6} GH increases the oxidation of fat (lipolysis). The transport of glucose into body tissues is inhibited.⁵

GH increases blood glucose concentration by decreasing cellular uptake and utilization and by increasing hepatic glucose output. Cellular utilization of glucose is decreased by inhibition of phosphorylation. This action tends to conserve glucose and is made possible by the lipid mobilizing action of GH.⁶

GH stimulates protein synthesis and tissue growth. It stimulates amino acid uptake by cells and the incorporation of amino acids into protein. Animals receiving GH have higher energy requirements for maintenance, growth and production due to the higher protein deposition rate and greater lean body mass. These factors also decrease the energy available for lipogenesis.⁸

Growth hormone may also be important in the functioning of the immune system. It is thought to enhance functional activities of lymphocytes and to be necessary for maintaining lymphocyte populations in lymphatic tissue.²

Effects on lactation in dairy cows

Injection of BST into dairy cows has increased milk production by as much as 40% in some instances.⁴ In another study the stimulation from a prolonged release formulation of BST increased fat corrected milk by 20% as compared to control animals. The milk composition was unchanged except for a slight increase in milk protein. Dry matter intake was increased but feed efficiency was essentially unchanged.¹⁰

BST treated cows have increased synthesis of lactose, fat and protein in the mammary gland. These changes have been shown to be associated with increased cardiac output and increased mammary blood flow.⁴ It

is believed that the overall galactopoietic action of BST is associated with increased partitioning of nutrients for milk synthesis which is later followed by increased voluntary feed intake.^{4,5,12}

BST also alters the partitioning of mineral nutrients in the bovine. The levels of calcium and phosphorus in milk are not changed, therefore greater total quantities are secreted. This requires either greater absorption from the alimentary tract or greater mobilization of skeletal reserves or a combination of the two. Eventually, voluntary intake must increase to match the output. As is the case with energy and protein supplying nutrients, there is considerable variation among individual animals both in feed intake and in partitioning of nutrients among body tissues.⁴

Effects of PST on pork production

PST affects the growth performance and body composition of swine. Marked improvements in daily gain, feed efficiency, carcass lipid content and lean body mass have been reported. Many of the PST effects are accounted for by decreased lipogenesis and continuing lipolysis. These effects are apparently independent of energy intake.⁸ Some studies have shown that pigs treated with PST had lower dressing percentages, indicating a higher percent of visceral organs. The increases were found to be in the liver, kidney and pancreatic tissues.¹⁴ Some differences have been reported in the proprietary qualities of pork from pigs treated with PST. Scores for juiciness, tenderness and flavor have been lower in some studies, particularly in pork from pigs receiving higher doses of PST.^{15,16}

Food safety

BST has been demonstrated to be inactive when administered systemically to humans. All mammals produce their own species specific somatotropin. Each has a different amino acid sequence. The FDA has approved the sale for consumption of milk and meat derived from cows treated experimentally with BST. Milk from BST treated animals is similar in composition to milk from untreated cows. No health or environmental issues have emerged that are likely to keep BST products from earning FDA approval.¹⁷

Animal health

Long term growth hormone treatment may lead to acute or chronic animal health problems such as ketosis, chronic wasting, hepatic lipidosis, infertility and increased susceptibility to infectious diseases.⁴ This would seem to be particularly true if adequate nutrition is not provided to meet the demands of increased production. Several trials have been completed, however in which no deleterious effects were noted.^{4,10,11} Thus it seems clear that GH can be successfully used as a management tool without causing an increase in animal health problems.

Increased somatic cell counts have been noted in cows treated with BST in some trials but this has not been a consistent finding and may in fact have been unrelated to use of GH. Some degree of heat intolerance has also been reported with the use of BST during hot humid weather.^{3,18}

Some studies have shown BST to have no effect on reproductive function in cows as measured by number of days to first estrus, pregnancy rate, embryo loss, calf development, gestation length or birth weight of calves. Other studies have shown small increases in days open, calving interval and services per pregnancy. It is thought that any negative effects of BST on reproduction are most likely the result of an energy deficit rather than any direct effect on reproductive function.^{3,10,11}

Studies using relatively high doses of PST on gilts have resulted in impaired ovarian development and delayed estrus.¹³ More work in this area may be indicated but it appears that at the present time PST should not be used on replacement gilts.

PST treated swine have been found to have increased mortality in some studies,^{2,9} but this has been an inconsistent observation. Other studies have reported an increase in severity of osteochondrosis or increased osteochondrosis-like lesions.²

Socioeconomic impact of somatotropin

Sufficient evidence is available to indicate clearly that somatotropin can be successfully used as a management tool in animal agriculture. The economic impact and the societal changes that will be associated with

widespread use of the products are matters of great concern at the present time and are as yet untested.

One study suggests that by the mid 1990's fifty percent of American dairy herds may be receiving BST.¹⁷ Another study suggests that by the year 2000 approximately 50 percent of current dairy farmers in this country will have been forced out of business by the economic effects of BST. Average annual milk production is projected to be 20,400 pounds in BST treated cows as compared to 16,300 in untreated cows. The increased production is anticipated to exceed the national demand for milk and milk products.¹⁹ Presently two state legislatures (Minnesota and Wisconsin) have banned the use of BST in dairy cows for at least a one year period of time. Several other state legislatures have mandated labeling for milk from BST treated cows.

It appears likely that FDA approval of both BST and PST will be forthcoming but presently there is concern over what delivery systems will be used. Reluctance has been expressed over approval of repository or long acting formulations of these products. Likewise, industry acceptance of products requiring daily injections is questionable at best. The cost-benefit ratio has been estimated to be in the range of 1:3 to 1:5 for BST¹⁹ however, and if this can be achieved it is difficult to imagine that progressive producers will choose to reject the technology.

The veterinarian's role

Veterinarians must be prepared to advise producers on the uses of somatotropin in dairy animals and pigs. Health management programs will be needed that take GH use into consideration.

It appears likely that BST treated cows will resemble those in the rising phase of lactation with respect to nutritional needs, reproductive capacity and susceptibility to disease. Herds with superior management but limiting genetic potential might be expected to respond well to BST. On the other hand, herds in which management is already limiting may respond poorly to BST.¹⁸

Cows that are in negative energy balance in early lactation probably should not receive BST. For most producers this may

mean withholding treatment with the product for the first 60 days of lactation. Likewise, animals that are in poor condition should not receive BST. It is anticipated that BST treated cows will have a greater persistency of the lactation curve and will produce more milk in the latter part of lactation.

Dry matter intake increases 3-15 percent in BST treated cows after an initial four to six week lag.²⁰ Feeding strategies will need to be developed to insure the proper nutrient intake without adverse effects on the animal.

If mammary capacity is a limiting factor it may be necessary to use three or more milkings per day to realize the beneficial effects of BST in individual animals. BST will certainly not be indicated for all cows in given herds. It would appear that BST would be most useful in cows that drop off too rapidly in milk production, do not peak, experience prolonged calving intervals or gain excessive body weight.

Similar problems can be expected in adapting to the use of somatotropin in swine. It would be expected that needs for amino acids and non-specific nitrogen would increase in growing swine on PST due to "tissue repartitioning". A recent study showed no significant difference in performance of growing swine on 19 percent protein as compared to a 16 percent protein ration however.¹⁴ It does appear that PST should not be used in gilts intended for breeding. It also appears that the delivery system will be critical in determining producer acceptance of PST for swine.

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